Evolution of Technology:

Exposing the Myth of Creative Design

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Evolution in the biological world has been pretty much accepted. Those who once argued against it have settled down. Most people now accept that our existence is the result of an extremely long history of evolutionary process. This process is responsible for the diversity among species on this planet, and is also responsible for the development of conscious, creative human minds.

In the past, evolutionary theories of biological life have been resisted for a number of reasons. One of these reasons is that it challenged our ancestor's view of themselves and humanity's place in the universe. If evolution is true, then it seems that we humans are not the result of purposive design -- rather, we are the result of an inconceivably long history of inheritance of random change. In the past, many thought this view was unacceptable. Even today, some people find the view unpalatable and insist that the human species is the result of intelligent design. Despite the resistance, however, scientific discovery has given us good reason to suppose that evolution by natural selection takes place. Fossil records, DNA analyses, and experiments with short generational span bacteria are examples of empirical data that can best be explained by evolution in the biological world (see the Lenski Lab http://www.msu.edu/~lenski/ for experimental research on bacteria).

Does evolution remove humanity from its special place in the cosmos? It could be said that the truth of evolution does not alter the fact that humans, unlike other species, possess *creativity*. We have the ability to produce beautiful music, paint scenery, write poetry, and design artifacts. For most people, the common sense view of the human mind is that it is a source of *intellectual originality*. In addition to its artistic abilities, it can use its creativity to *design* technological devices that serve specific purposes. There are many examples of technology that has been designed to serve a specific function. Consider the watch (a well worn, but effective

example). People needed to tell the time so they set about designing a timepiece. After many experiments and many design alterations our ancestors developed the first timepiece.

In this paper, I will argue that the common sense view of the human mind is wrong. I will suggest that human creativity is a myth -- or at best, an illusion. To begin, I will outline the theory of evolution and will show that it can be applied to non-biological systems. I will then examine the so-called creative process, and will attempt to discover the mechanisms involved in designing technological artifacts. My conclusion will be that technological artifacts are not the result of creative thought -- rather, the creative process can more accurately be described as the execution of an evolutionary algorithm.

1. What is Evolution?

Let's quickly run through the theory of evolution. The beauty of evolution is its simplicity and its portability to a number of domains. Once you understand how the system works, you can see that it can be applied to several different fields of enquiry.

Charles Darwin is thought to be one of the first people to theorize about evolutionary process. His ideas were published in his famous "On The Origin of Species by Means of Natural Selection" in 1859 and have resulted in a drastic change in the way we think about our place in the universe. For such an influential theory, however, evolution is based on surprisingly few premises:

1) In ideal circumstances (limitless resources), populations will grow exponentially.

2) Resources are limited.

3) Because resources are limited, populations tend to remain stable.

These first three premises were formulated by Thomas Malthus in his essay on the principle of population. The remaining premises are Darwin's additions.

4) Individuals within a population have unique characteristics.

5) An individual's characteristics are passed on to its offspring (inheritance).

6) Change can occur, and this sometimes results in offspring having slightly different characteristics to their parents'.

7) Given the fact that individuals have varied characteristics, it is

reasonable to suppose that *some* individuals will have characteristics that give them a better success at acquiring resources and reproducing.

8) Given premise 5, it is reasonable to assume that characteristics that enhance an individual's survival and reproductive success will be passed on to subsequent generations -- this is *Natural Selection*.

9) Evolution is the result of this process.

10) Populations that posses the above characteristics will evolve.

(This list has been adapted from a list provided by Herbert, T. (2000) Historical Perspective, Darwin and Evolution).

You will see that there is no requirement for the population to be one of biological entities. The above system can be applied to a number of different population types. All you need for the system to work is a population of entities that are: 1) competing for resources, 2) have unique characteristics, 3) can reproduce, 4) produce offspring that inherit their characteristics, and 5) whose offspring might be different. This is to say that the offspring may find themselves with characteristics that their parents did not have -- perhaps through some sort of random mutation, the details of which are not important here.

In the following sections, I will compare the biological world to the world of ideas. With the comparisons I draw, I will show that technology has developed according to the above evolutionary system.

2. How do you build a watch?

How do you *build* a piece of technology, say a wristwatch? The answer to this is obvious. You follow a list of instructions. These instructions will tell you what sort of hardware to purchase and how to put it together to produce a functional watch. If you want to go any further and ask "why" the watch does what it does, you simply have to appeal to its *designer*. The watch tells the time because that's what its designer intended it to do. Perhaps you purchased your instructions from a company like 'ACME' (the one that supplies the coyote with road runner catching equipment -- remember the old Warner Bros cartoons). You know that a lot of very clever people work at ACME, and so you know that if you follow the instructions correctly, you will build a fully functional watch. You don't need to understand how it works, because someone at ACME has already figured it out.

But what if you had no instructions? What if you had never seen a watch before? Now, ask the same question again. *How* do you *build* a wristwatch? The answer in this case is not so easy to find. Think about it,

and you will probably find yourself seeking answers that rely on the existence of earlier examples of wristwatches -- or at least some knowledge of the passage of time. You might think to yourself that you would build a watch that is something like an old grandfather clock, just much smaller. Or perhaps you will design your watch based on the timing of the sun crossing the sky -- thereby utilizing your knowledge of the rotation of the Earth. But suppose these things do not exist. Suppose you have never considered the passage of time -- perhaps the Earth does not rotate -- and timepieces have not yet been invented. In such a scenario, would it be possible to design and construct a wristwatch? I think the answer is no! Given your lack of knowledge about the passage of time, it seems that you would not even be able to conceive of the *need* for a wristwatch, much less design one from scratch. It seems difficult to believe that someone with no prior knowledge of watches could sit down and design a wristwatch, or any other sort of timepiece. But wait. Wristwatches exist, don't they? They didn't design themselves and they did not appear out of thin air, so surely *someone* must have designed them. If not, how could we explain their existence? Was it God? Or are we missing something?

Let's turn to the biological world and ask an analogous question. How do you build an animal, say a dog? If you are a scientist in a laboratory, you might answer the question in the same way as before. You follow a list of instructions. In the case of animals, the list of instructions is known as a genome. The genome is an incredibly large collection of genes. Genes are chemical instructions, encoded in DNA (Deoxyribose Nucleic Acid) that direct the development of cells. A fertilized egg will contain genetic information from both its parents, for example a male and female dog. As the egg cells divide (first into 2 cells, then 4 cells, then 8 cells, and so on), they chemically read the instructions that are contained within their genetic blueprint. These instructions tell them how to develop. Some will become skin cells; some will become brain cells, and so on and so forth. Eventually a fetus is formed, then a cute puppy, then a fully functional adult dog.

Now let's ask the further question: *why* does the dog behave and look the way it does? Unlike the wristwatch case, we cannot appeal to a designer because in the case of dogs the idea of a designer simply does not enter the picture. Dogs were not designed. Nevertheless, it is a good question and evolutionary biologists can provide us with an answer. The dog behaves and looks the way it does because of the genetic instructions that were used in its construction. But these genetic instructions were not provided by a designer. They are the result of an incredibly long history of subtle modification of earlier instruction sets. It is important to emphasize that these modifications were not guided by an intelligent process. They were the result of random change and transmission to offspring. A run down of the process might go something like this:

At some point in history, an ancestor of the contemporary dog existed. One day, one of these early dogs gave birth to offspring whose genetic instruction sets were ever so slightly different (perhaps because of some mutation due to something in the environment, or perhaps because the copying mechanism is not perfect). The difference may have been almost undetectable -- perhaps they had a slightly enhanced sense of smell. Now, because of their better sense of smell, these offspring were a little better at avoiding predators, finding food, and finding mates (very important for us mammals). Since genes are passed on to offspring, the change in the instruction set was reproduced in subsequent generations. Hence, dogs got better at using their noses.

An important point that is often misunderstood here is that the development of slightly different characteristics *does not necessarily lead to the extinction of animals that posses the original characteristics*. They may continue to reproduce effectively for millions of years. Furthermore, descendents of the original animal may one day give birth to something that is slightly different in other ways, and it too will pass on its features to its offspring (if it manages to reproduce, of course). And thus we get a 'branching' effect in the history of life on Earth.

Genes are the key to this system. They provide the instructions for how to build an animal. They are reproduced in offspring, and sometimes they change. The genes that get themselves reproduced effectively -- perhaps by providing a creature with a better sense of smell -- are the ones that survive. Less successful genes, for example genes that reduce eyesight in dogs, will tend to have limited reproductive success and will tend to lose their representation in the *genepool* (the total gene set on Earth).

The explanation works well. By iterating (repeating many times) a very simple process of subtle change and inheritance, we can account for the existence of extremely complex, well adapted dogs. Could a similar answer work for technology? Can a technological artifact such as a wristwatch be broken down into a collection of small components like genes? Is it possible to account for technology by grouping large numbers of these small components together? The answer to this question can be found by appealing to the study of *memetics.*

2.1. Selfish Memes

In his 1976 book *"The Selfish Gene"*, Richard Dawkins introduced an entity known as a *meme*.

Memes are entities that primarily inhabit human minds (but you can find them in other places as well). To express it simply, a meme is an idea. Some modern day examples of memes are musical phrases, jokes, trends,

fashions, car designs, and poetry. Any thought or idea that has the capacity to replicate is a meme. A well used example of a meme is the first four notes of Beethoven's 5th symphony. Another example is the "Happy Birthday" song. These are ideas that inhabit our minds and have been very successful at replicating. Not only have these memes found their way into literally millions of minds, they have also managed to leave copies of themselves on paper, in books, on audiotape, on compact disks, and in computer hard-drives.

At first glance the idea of a meme may seem trivially true. Of course ideas spread, what's the big deal? Well, the big deal is that memes behave in similar ways to genes, and in this way their behavior and development can be described in terms of evolution.

Like genes, memes are in competition with each other. While genes compete for representation in the genepool, memes compete for representation in the *memepool* -- the huge collection of ideas that are currently circulating the world. Human minds have limited room, so only the best memes manage to implant themselves. Memes that are good at replicating tend to leave more copies of themselves in minds and in other mediums such as books. Memes that are not so good at replicating tend to die out. There is a gigantic history of extinct memes, but since they are extinct we do not know what they were. To know what they were and to mention them here would only be possible if they were still circulating in the memepool. But we can imagine what sorts of things they were. Ancient songs that were once sung and never written down are one example. Another example is the many stories that were once told but have since slipped into oblivion. A Story is a vast collection of memes (a memeplex), which are subject to the same selection pressures as other memes. If they replicate through the story getting told and read by people, then they will survive. If they stop getting read, they die. Libraries are full of memetic fossils in the form of books that contain a multitude of ideas that are never looked at.

The memes that replicate the best are the ones that manage to fit into existing collections of memes. Music is a great example (see Dennett (1999) for an interesting examination of the evolution of music). Contemporary music conforms to a set of rules. If a song were produced that followed an entirely alien set of rules, it would not fit in with our existing set of ideas about music and would probably die out. But if a new song appears that follows all the rules, then it will fit in nicely and will copy itself from mind to mind and to CD's, MP3's, and hard-drives. New songs are collections of memes that have been formed through the subtle change of existing memes. This change may be the result of some sort of blending of ideas or random mutation perhaps resulting from imperfect copying. The result is a slightly different song that contains memes that are competing for representation in the memepool.

An important point to note is that memes replicate for their own sake and not for the sake of the minds they inhabit. If a meme appeared that resulted in people carrying out life threatening activities, it *could* still be successful if it managed to transmit itself to other minds before its host died. Some examples of such memes might be the ideas involved in parachuting, high speed motor racing, smoking cigarettes, or taking other dangerous drugs. The memes do not care about the danger that people face when carrying out these activities. Memes are simply reproductive entities. If there is something about a meme that makes it good at getting copied into other minds or into other mediums, then it will continue to exist. If it mutates and produces a meme that is slightly better at replicating then the new meme will compete more effectively for representation in the memepool -- an event that could lead to the demise of an older meme.

Many thinkers have resisted the idea of memes on the grounds that it is not possible to determine exactly *what* the meme is. We know that it is an idea that replicates, but how can we *point* to a meme? How can we isolate a memetic unit? This is a valid question. After all, there seems to be big differences between memes such as the first four notes of Beethoven's fifth symphony, the phrase "You're damned if you do, and you're damned if you don't", and the behavior of shaking hands. How can each of these be considered to be single memes? A similar problem arises when scientists talk about genes. There is no real gene 'unit'. Genes are packets of information that are encoded in DNA. Distinct genes can vary markedly in length. The same goes for memes. Memes are best thought of as packets of information that can be encoded in a number of different mediums. They can be encoded in the complex neural architecture of the brain, and they can be encoded in magnetic patterns on a hard-drive. A memetic 'unit' can be described as a *self-contained information packet that reproduces*. So, the first *three* notes of Beethoven's fifth symphony do not constitute a meme because it is not a self-contained information packet that reproduces. The *fourth* note is required to complete the reproductive unit. Of course, the question of the rest of the symphony now arises. Is it made up of a multitude of four note units? The answer is no. The symphony *is* made up of a vast collection of memetic units, but they are all different lengths. The entire symphony constitutes a memeplex that has good replicative power, but many of the individual memes would not make it alone. Some do, however -- you often find small pieces of music reproduced in other work -- but for the most part, the memes are dependent on their counterparts in the memeplex for survival. It is possible that the memes that comprise the fifth symphony memeplex were common in Beethoven's day. He was undoubtedly influenced by the tunes and musical themes of his time, and these would have found their way into his work. Even though they would no longer survive on their own, they manage to survive by being a part of the large

symphonic memeplex that continues to reproduce.

3. Does Memetics fit in with the Evolutionary Theory?

Now, let's consider evolution's premises (see section 1 above) and apply them to memetics. Is the evolution of ideas plausible?

The first premise states that in ideal circumstances, populations grow exponentially. In the case of memetics we can see that this is true. If you have an unlimited population of communicating minds -- ideal for memes -- then the population of memes *would* grow exponentially. Communication would ensure that the memes are continually replicated and implanted in new minds. If an idea appears in one person's mind, and she transmits it to everyone she knows, who in turn transmit it to everyone they know, you get an exponential growth in replication of that meme -- hence the memetic population grows exponentially.

Premise two states that resources are limited. This is obvious in the case of memetics. There are a finite number of vehicles for memes, which include minds, written text, pictures, and objects like wristwatches.

In premise three, we state that limited resources lead to the stability of population. It is difficult to see that this is true of memetics because the memepool is continuing to grow. New people are being born and are continuing to create new ways of storing memes. Despite this, however, the memetic population is reasonably steady. Old ideas disappear and are replaced by new ideas -- there simply isn't the room for all of them to exist and keep replicating.

Premise four is very important. It states that individuals in a population have unique characteristics. The uniqueness of memes is obvious. Some memes are similar, but others are extremely different. Consider the difference (mentioned above) between the first four notes of Beethoven's fifth symphony and a behavior such as shaking hands when meeting people. These are distinct memes with unrelated, unique characteristics. One manifests itself as a sequence of sounds, either imagined or real, while the other manifests itself as an action.

From premise four we can go on to show the truth of premise five -- that an individual's characteristics are often passed on to its offspring. In the case of the hand shake, the meme reproduces when people observe the behavior and imitate it. Imitation keeps the characteristics of the behavior intact while copying the meme into the mind of the imitator. Whether it survives in the new mind is another question that depends upon the behavior being carried out again. Of course change can occur, as premise 6 goes on to state. This can be the result of memes merging with existing memes, or perhaps because of imperfect copying of the original meme --

sometimes stories change; sometimes behavior is not imitated accurately. Such changes give rise to new memes that compete to get them selves expressed and reproduced.

This brings us to premise 7, which states that some individuals will have characteristics that give them a better success at acquiring resources (minds, paper, hard-drives) and reproducing. Some memes enter minds and get stuck there -- never finding a way out -- until they degrade and disappear. Consider, for example, a joke that you might have heard several years ago. It's memetic structure copied itself into your mind, but for some reason it did not compete well with the memes that were already there. Consequently it never found an outlet. There was always something else that was more important to say -- more successful at reproducing. Eventually the joke's memetic structure degraded and faded away. Fortunately for the joke, many other people probably *did* utter it, and its propagation continued in the minds of others. But this is not always the case. There is an enormous history of memes that were once effective replicators but eventually died out because they could not compete with other memes. Old songs from the second century were probably very good survivors, until they were eventually replaced by memes whose characteristics that enhanced their own reproductive success.

Now, given the fact that a meme's unique characteristics are passed on to its descendants, and given the fact that only the best survivors get to reproduce, we can assume that characteristics that enhance reproductive success will appear in subsequent generations. This process, as stated in premise 8, is known as *Natural Selection.*

The result of the process outlined here is memetic evolution.

Now that we have a definition of memetic behavior, and given the idea of what constitutes a memetic unit, we can turn our attention back to the development of the modern wristwatch.

4. A Brief History of Timepieces

Deep in our history, humans had very little understanding about the passage of time. We can suppose that their only real knowledge of time was that when it got dark, they went to sleep. This sort of behavior is innate and so does not fall under the category of memetics. One day, however, a human might have accidentally discovered a new use for watching the sun. This primitive person might have realized that lions and tigers do most of their hunting at dusk. If this happened, a new behavior would probably have emerged -- a behavior that would have led this intelligent person to seek shelter when the sun reached a certain position in the sky. Now humans, unlike most animals, have the ability to acquire

new behavior through *imitation*. When members of the group noticed their friend seeking shelter in response to the changing position of the sun, some would have copied that behavior, thus giving rise to the transfer of the '*action at a specific time*' meme.

As the centuries passed, more time dependent behavior would have surfaced. The behavior that copied itself into the minds of many individuals tended to continue reproducing, while behavior that stopped occurring did not get imitated and eventually died out. Looking at the position of the sun to determine what action to take is a behavior that was very successfully copied into the minds of most of the human species. Eventually the 'look at the sun meme' mutated. Somehow it got merged with other ideas that were circulating, and gave rise to an idea that involved looking at the shadow of a stick for a more accurate impression of the passage of time. In time, the 'look at the shadow of a stick' meme was influenced by other memes that were appearing and developing at an exponential rate. Memes for constructing items out of stone and memes for using symbols to represent different times of the day, blended with the 'look at the shadow of a stick' meme to produce new memes that eventuated in the construction of the *sun-dial*.

Later in history, a gigantic collection of memes were at work producing mechanics and devices that were made from moving parts, like the water wheel and the windmill. Through some incredible combinations of memes, the mechanical memes became attached to the sun-dial memes and produced the first clock. A huge number of variations of the clock appeared prior to the appearance of the modern wristwatch. Ideas were adjusted as they were influenced by other ideas, and this process led to the refinement of the clock. Many early versions did not work very well and were not reproduced. Memes that led to the failure of early clocks did not appear in later versions and subsequently became extinct.

The modern wristwatch can be described as a collection of successful memes -- the ones that survived. When a watchmaker builds a new watch, he/she is not 'creating' or 'designing' something from scratch. He/She is pulling together a bunch of memes that have slowly evolved since the first humans noticed the sun's movement across the sky. The modern wristwatch owes its existence to the gradual evolution of memes -- an evolution that was driven, in part, by trial and error experiments on existing memetic constructs.

5. A Concluding set of Memes

I have attempted to show that the idea of creative design can be replaced with an evolutionary picture. The basic premises of evolutionary theory are not exclusive to the biological world, and can therefore be applied to

other domains. In this paper, I have run through a description of memetics, and have shown that memes (or ideas) evolve in a similar fashion to genes. My aim has been to show that technological devices, such as the wristwatch, are a collection of memes that have evolved over the course of human history. If the assumptions I have made are correct, and if evolutionary theory is correct, then it seems that human creativity can be replaced with memetic evolution.

The human mind is full of memes that are competing for resources. The most effective memes are those that get themselves reproduced. So, in the case of the wristwatch, we can suggest that the designer's mind was buzzing with memes relating to previous versions of timepieces. Some of those memes were very good at getting themselves expressed, and in doing so, found themselves incorporated in the design of the wristwatch. The memes that were not so effective at getting expressed (for example the idea of attaching the watch to one's jacket via a chain) were not included in the new design and are now dying out.

Where did these wristwatch memes come from? Well, they originated deep in human history and looked much different than they do today. They jumped from mind to mind through the process of imitation. Sometimes they would change ever so slightly; perhaps by being influenced by other memes, or perhaps through imperfect imitation. Thousands of years of memetic transfer resulted in the memes that comprise the modern wristwatch. It was just a matter of time before they all accumulated in one mind, and the wristwatch was born.

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